NOAA Activities in Support of the NASA GPM GV Program

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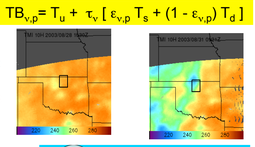
Overview:
NOAA is contributing to the NASA GPM Ground Validation effort through a variety of activities conducted in three of the NOAA Line Offices: National Weather Service (NWS), National Environmental Satellite Data and Information Service (NESDIS), and the Office of Oceanic and Atmospheric Research (OAR). These activities, described in detail below, include improving satellite retrieval algorithms, developing, testing, and evaluating precipitation products, and developing new forecast model assimilation techniques. In addition to contributing to fundamental research on precipitation and hydrologic processes through participation on the NASA PMM Science Team, NOAA intends to use GPM data to deliver improved precipitation and hydrologic products and services.

Land Surface Characterization for GPM-era Algorithms

Ralph Ferraro, NOAA/NESDIS, Nai-Yu Wang, Univ. Maryland/CICS

- To improve land surface precipitation retrieval algorithms (esp. for light rainfall and snowfall), vastly improved surface characterization is needed
  - The main driver is the surface emissivity, ϵ
- For algorithm development, GPM GV measurements of ϵ, (or proxy info. Like Ts and soil moisture) are desirable
- Key scientific questions include:
  - What are the limiting factors for onset and light precipitation rates
  - What happens to ϵ when active precip. is falling?
  - What is the best way to represent this data within the Bayesian retrieval scheme?

$TB_{v,p} = T_u + \tau_v [\varepsilon_{v,p} T_s + (1 - \varepsilon_{v,p}) T_d]$



GPM Radiometer Algorithm → S0, S1, S2

- S0, S1, and S2 requires increasing knowledge of surface emissivity.
- S0 is EOF-based and is as surface "blind" as possible to surface Variability
- S1 uses monthly grid surface emissivity Classes
- S2 uses high quality land surface emissivity models that accounts for dynamic hydrology and vegetation changes.

GPM S1 Bayesian Retrieval (GPROF)

At Launch Semi-Physical Database (TBs, rain rate, hydrometeor profiles)

Conical scanning radiometers: TMI PR MMF/ SDSU CSU | SSMIS NMQ MMF/ SDSU N-Y Wang | AMSR-E CloudSat MMF/ SDSU M. Kulie J. Munchak

Cross-track scanning radiometers: MHS CloudSat MMF/SDSU C. Kidd/J. Turk

CMORPH Integrated Global and Regional Precipitation Analyses

P.Xie and R.Joyce

- **Targeted Techniques / Products Developments**
  - *Pole-to-pole CMORPH for both rainfall and snowfall*
  - *Regional CMORPH on a finer resolution over NA with reduced latencies through fusing GOES-R observations*
  - *Gauge-Radar-Satellite-Model blended analysis of hourly precipitation over CONUS and adjacent regions*
- **Requirements for GPM GV activities**
  - *GV data used to examine how to quantify error for L2 retrievals as a function of sensor type, precipitation type / intensity, season, and location;*
  - *GV data used to examine how the error is propagated in constructing Le products*
  - *GV data used to define how to determine the type of precipitation (rainfall / snowfall) as a function of atmospheric state variables*
  - *GV data used to define the error for other commonly used 'ground truth' (e.g. radar estimates, gauge analysis)*
- **'Ground Truth' data that we generate and may be useful for GPM applications**
  - *CPC unified global daily gauge analysis (operational)*
  - *CPC unified global temperature analysis (in construction)*
  - *CPC hourly gauge analysis over CONUS (in construction)*
  - *Daily snowfall analysis over North America (in development, with Groisman at NCDC)*

CLIMATE PREDICTION CENTER

GPM GV Related Research

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Toward the development of Climate Data Records for precipitation: Characterization of CONUS rainfall using a suite of satellite, radar, and rain gauge QPE products

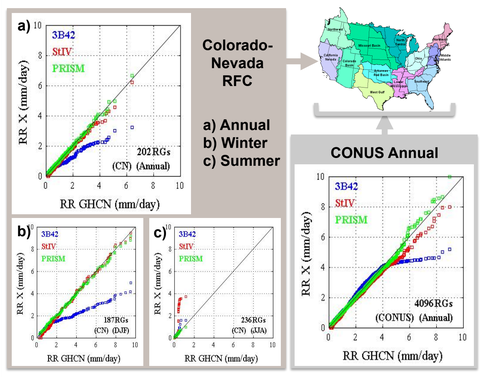
We use a suite of quantitative precipitation estimates (QPEs) derived from satellite, radar, surface observations, and models to derive precipitation characteristics over CONUS for the period 2002-2012. This comparison effort includes satellite multi-sensor datasets of TMPA 3B42V7, CMORPH, and PERSIANN. The satellite based QPEs are compared over the concurrent period with the NCEP Stage IV product, which is a near real time product providing precipitation data at the hourly temporal scale gridded at a nominal 4-km spatial resolution. In addition, remotely sensed precipitation datasets are compared with surface observations from the Global Historical Climatology Network (GHCN-Daily) and from the PRISM (Parameter-elevation Regressions on Independent Slopes Model), which provides gridded precipitation estimates that are used as a baseline for multi-sensor QPE products comparison. The comparisons are performed at the annual, seasonal, monthly, and daily scales with focus on selected river basins (Southeastern US, Pacific Northwest, Great Plains). We also investigate the impact of differing spatial and temporal resolutions with respect to the datasets ability to capture extreme precipitation events. This work is part of a broader effort to evaluate long-term multi-sensor QPEs in the perspective of developing Climate Data Records (CDRs) for precipitation.

The slide presents the comparison of TMPA, St-IV, PRISM with surface observations from GHCN-daily for the annual precipitation over CONUS. While a good agreement is found for PRISM (expected because incorporate surface observation including GHCN) and St-IV, TMPA present a severe underestimation at higher rain rates (R~4 mm/day). Differences can be even more important when looking at the river basin scale (or River Forecast Center RFC) in particular in the West (Fig. a) and at the seasonal scale (Winter, Fig. b; Summer, Fig. c).

References:
- Prat, O.P., and B.R. Nelson, 2013: Characteristics of annual, seasonal, and diurnal precipitation in the Southeastern United States derived from long-term remotely sensed data. Atmospheric Research. In press.
- Nelson, B.R., O.P Prat, and D.-J. Seo, 2013: Assessment and implications of Stage IV QPE for product inter-comparisons. Journal of Hydrometeorology. To be submitted (10-2013).

NC State University

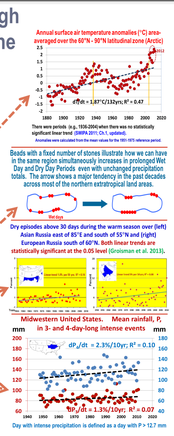
Comparison With Surface Observations (GHCN-daily)



Characterization of Precipitation Field in High Latitudes of the Northern Hemisphere for the Future Use with the GPM Products for Hydrological and Climate Change Assessments

P. Groisman NOAA/NESDIS/NCDC

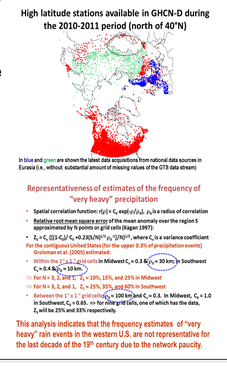
- Contemporary in situ meteorological network in high latitudes is prone to changes in density (closure of stations), instrumentation (new types of rain gauges), and reporting routines (varying biases). At the same time, climatic changes in the Arctic have been among the largest across the Globe.
- **We intend** to document dynamics of precipitation field in high latitudes of the Northern Hemisphere by updating, homogenizing, and bias-correcting available in situ precipitation data within a single archive of the "ground truth" regional (grid cell) precipitation values for the future use with the GPM products for hydrological and climate change assessments.
- The above-mentioned archive is (and will be) using to estimate intensity, frequency, and spatial correlation distributions of precipitation events in high latitudes and their dynamics in the ongoing climatic changes.



In situ Precipitation Dataset in High Latitudes of the Northern Hemisphere for Calibration of GPM Products (Ground Validation, GV)

- **Goal.** To document dynamics of precipitation field in high latitudes of the Northern Hemisphere by updating, homogenizing, and bias-correcting available in situ data for their future use with the GPM products for hydrological and climate change assessments.
- **GV data.** After their proper ground validation, GPM products will be providing an uniform coverage of the precipitation field. To serve this effort for the high latitudes of the Northern Hemisphere, we will compile, update and bias-correct data of a dense (as dense as possible) in situ meteorological network north of 50°N and estimate the actual accuracy of gridded in situ precipitation data sets for different selections of the grid cell sizes. The output of this analyses in the grid cells that satisfy representativeness criteria will serve as GV data for GPM products.

Final product. "Ground truth" regional (grid cell) precipitation time series together with estimates of the accuracy of this "truth" at the daily and monthly time scales.



NOAA GPM Proving Ground and HMT-SEPS

R. Cifelli and K. Mahoney (NOAA/OAR), R. Ferraro (NOAA/NESDIS), S. Rudlosky, (NOAA/NESDIS), P. Xie (NOAA/NWS)

- Purpose of the PG: test new algorithms and products, evaluate product performance and facilitate exchange of GPM products within NOAA
- Infrastructure will consist of ground-based instrumentation, (profilers, rain gauges, disdrometers, etc), computer networks, and NOAA personnel
- PG will combine resources across NOAA (NWS, NESDIS, and OAR) and leverage NOAA's testbed infrastructure, including the Hydrometeorology Testbed SE Pilot Study (HMT-SEPS)
  - HMT-SEPS extends from May 2013–September 2014 in western North Carolina with an aim on improving quantitative precipitation estimation (QPE)
  - HMT-SEPS provides an opportunity to test, evaluate, and compare QPE approaches (i.e., radar, gauge, satellite) as well as an opportunity to improve QPE algorithms
  - Goal: develop the best possible QPE forcing for operational users

More information about HMT: hmt.noaa.gov

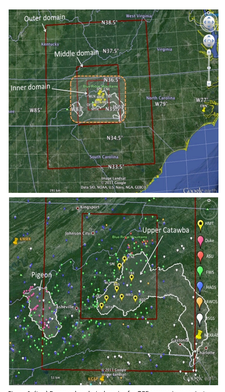


Figure 1. (top) Proposed analysis domains for QPE comparison project shown in red. Outline of Upper Catawba and Pigeon watersheds shown in white. Pin icons represent HMT-SEPS deployment sites. Approximate area shown in bottom image marked by shaded region. (bottom) Blow-up of HMT-SEPS region showing HMT sites as well as other network locations according to legend.

Table 1. HMT-SEPS site instrumentation.

Site Name	Site ID	Elev (m)	449	915	RASS	S-band	Met	Soil Moisture	Parsivel
Brindletown	BDT	355					X	X	X
Crossnore	CNE	1008					X	X	X
Hankins	HKS	379				X	X		X
Marion	MRO	384		X	X		X		X
Mount Hebron	MTH	519					X	X	X
New Bern	EWN	3	X			X	X		X
Old Fort	OFT	421	X		X	X	X		X
Spruce Pine	SPE	833					X	X	X
Table Rock	TBR	356					X	X	X
Woodlawn	WLN	523					X	X	X

GSD/FAB Project Summary

Earth System Research Laboratory, Global Systems Division

"Analysis and validation of GPM observations using a data assimilation system"

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[1]NOAA OAR/GSD/Forecast Applications Branch
[2] Cooperative Institute for Research in Environmental Sciences

Summary

Under the limited funding support ($50K), we are able to study what GPM radar data can improve on analysis using a data assimilation system.

- main effort is on research of forward operators for GPM radar data;
- the fast forward models found are difficult to implement into data assimilation systems due to the complexity or non-differentiability of the forward models (e.g., Matsui GPM simulator and others listed at https://sites.google.com/site/satellitesimulators/home);
- our research then focuses on if we can use Local Analysis and Prediction System (LAPS) 10cm radar operator for GPM radar data;
- one objective identified is how we can use GPM dual frequency radar data to analyze snow content (Liao et al. 2005);
- next step is to use LAPS operator to assimilate GPM for analysis and forecast improvement and validation of these radar datasets.

Forward models suitable for vLAPS testing

- Control variables rain, snow, graupel, cloud liquid, cloud ice
- Start with dBZ measurements from Ku band
  - Similar to TRMM radar, but more sensitive
  - Generally Rayleigh scattering regime, though may need corrections for large hydrometeors
    - Use LAPS/WRF conversions from hydrometeors to dBZ
- Up-front attenuation corrections, based on Ku and Ka band data, as well as microwave imager
- Ka band can see smaller hydrometeors, though would be outside Rayleigh scattering regime for most precipitation (Ka band is between Ku band and radar on CloudSat)
- Use radar reflectivity values and ambient temperature to help constrain hydrometeor type

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